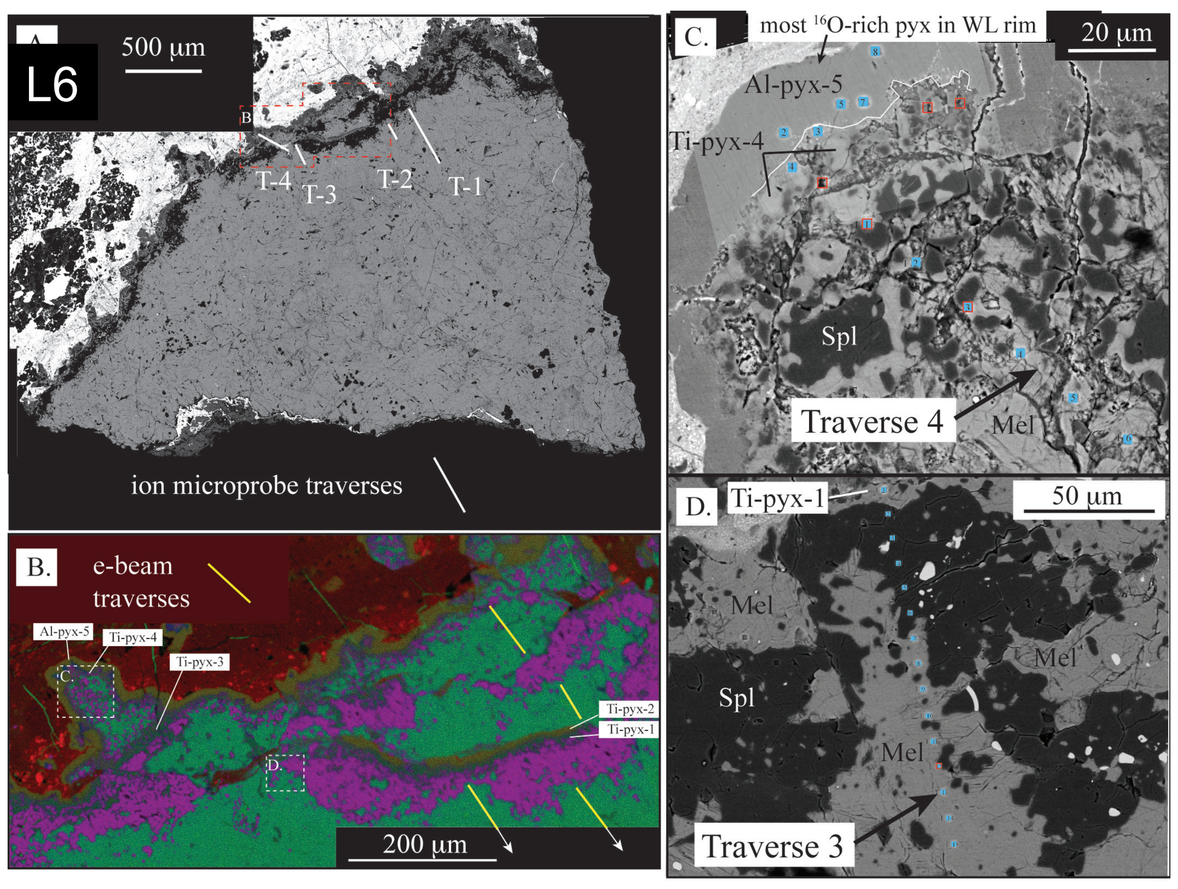
A Center for Isotope Cosmochemistry and Geochronology ARES, EISD, NASA Johnson Space Center

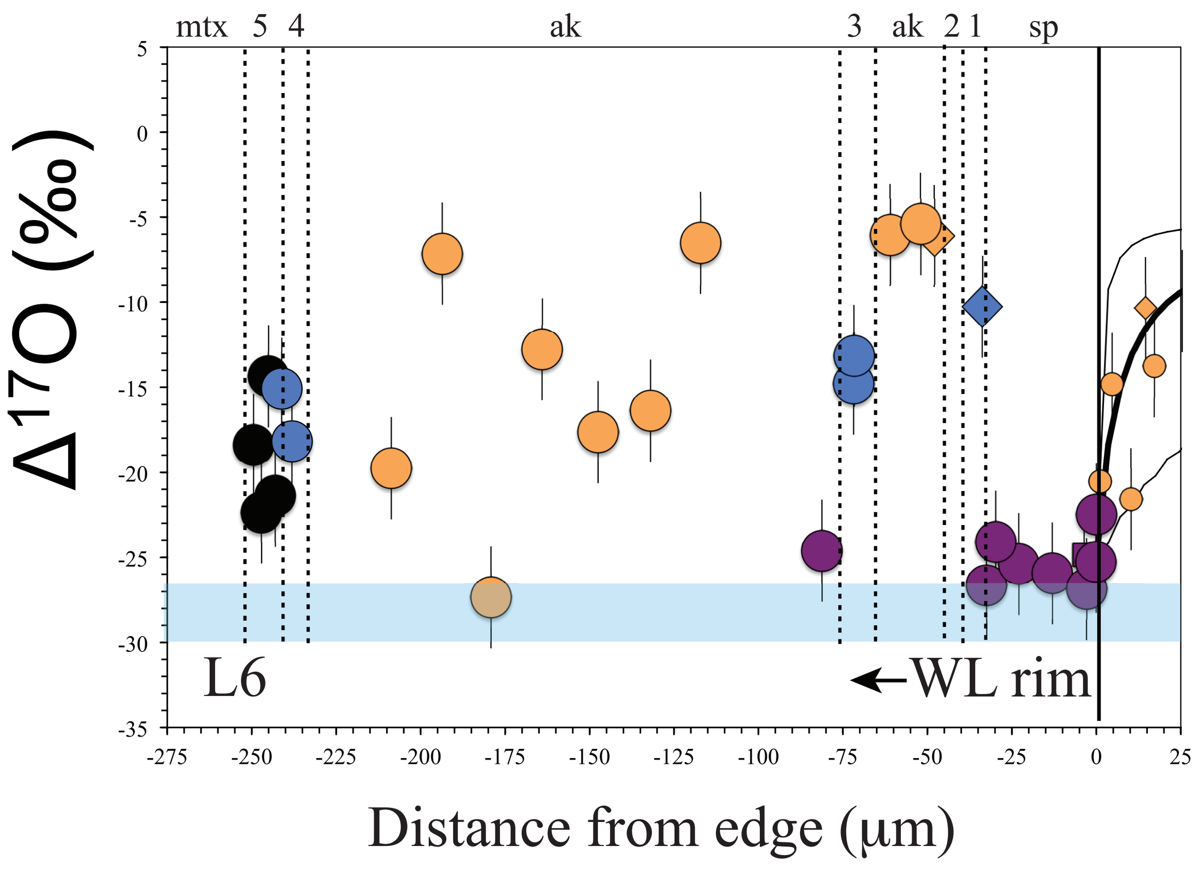
Principal Investigator: J. Simon; Scientists: M. Tappa, K. Ross, R. Christoffersen; Postdocs: T. Usui, R. Mills, T. Peters, J. Han, R. Mishra; Interns: P. Christoffersen, P. Srinivasan, K. Fisher, A. Tait, K. McCain

Primitive Meteorite Studies: Nebular Environments and Particle Transport within Protoplanetary Disks

Oxygen isotope heterogeneity measured in mineral layers surrounding refractory inclusions imply that CAIs either formed in regions where nebular gas varied in composition, or that they were transported across the protoplanetary disk.

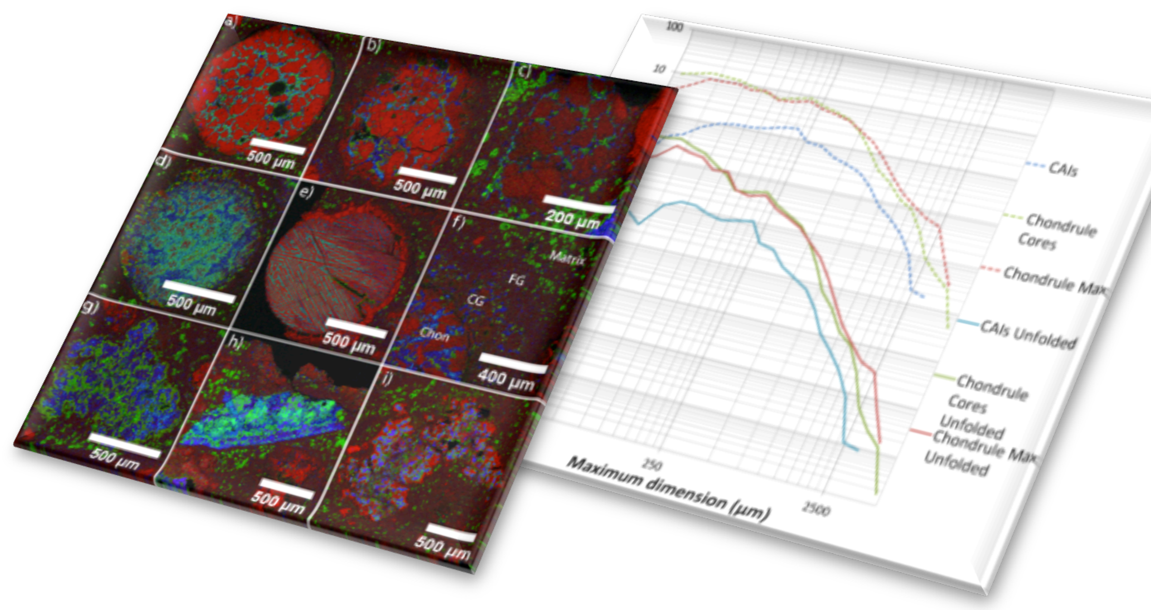


Complicated Wark-Lovering (WL) rim surrounding a Ca-, Al-rich refractory inclusion (CAI) called "L6" from the primitive *CV3* Leoville meteorite.



Oxygen isotopic composition measured by NanoSIMS within the WL rim layers of "L6" from left to right include: diopside (5), Ti-rich pyx (4), melilite (ak), Ti-rich pyx (3), zoned melilite (ak), zoned pyx (2), Ti-rich pyx (1), and spinel (sp). WL rim surround the melilite-rich interior (right side). Mtx is meteorite matrix.

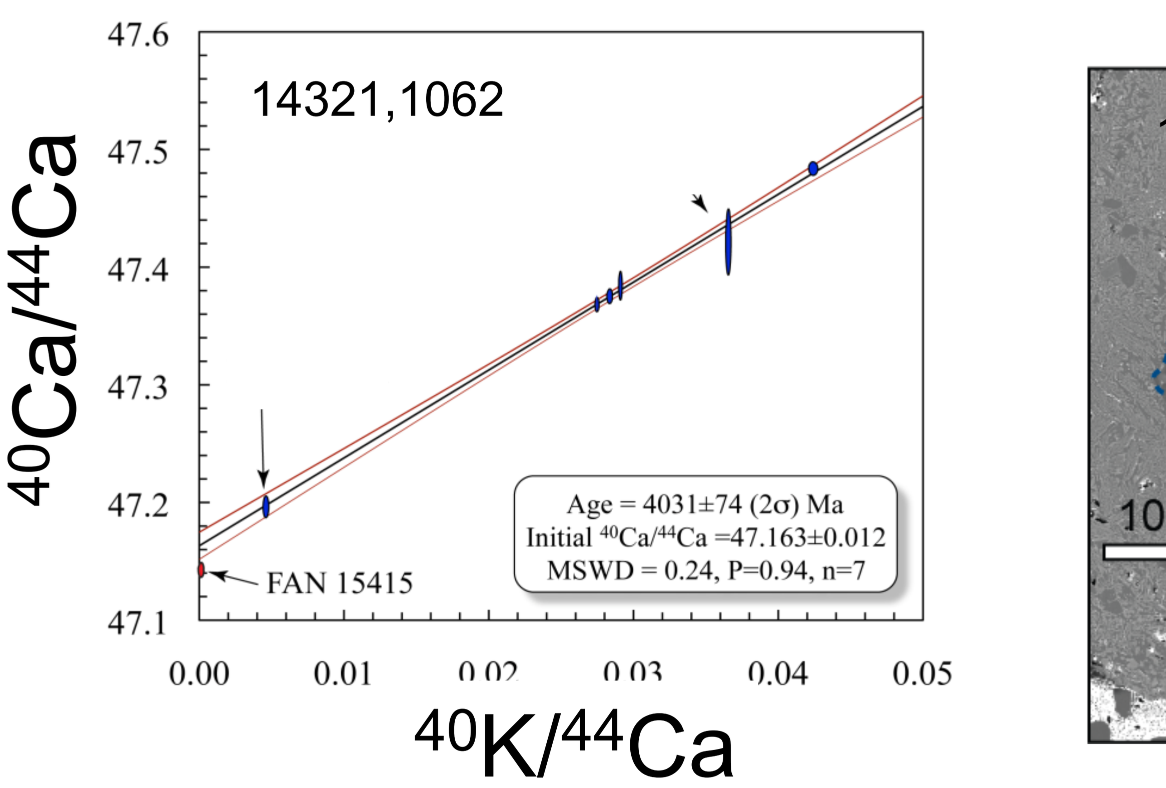
Integration of particle size analysis at micro and macro scales show that both CAIs and chondrules in Allende are much less sorted than previously reported.



Chondrite particle subtypes (left). 2D particle size distributions with corresponding 3D volume distributions (right). Did sorting processes occur in the nebula or during the accretion of the Allende parent body? By which mechanisms? These data will be used to test theoretical models.

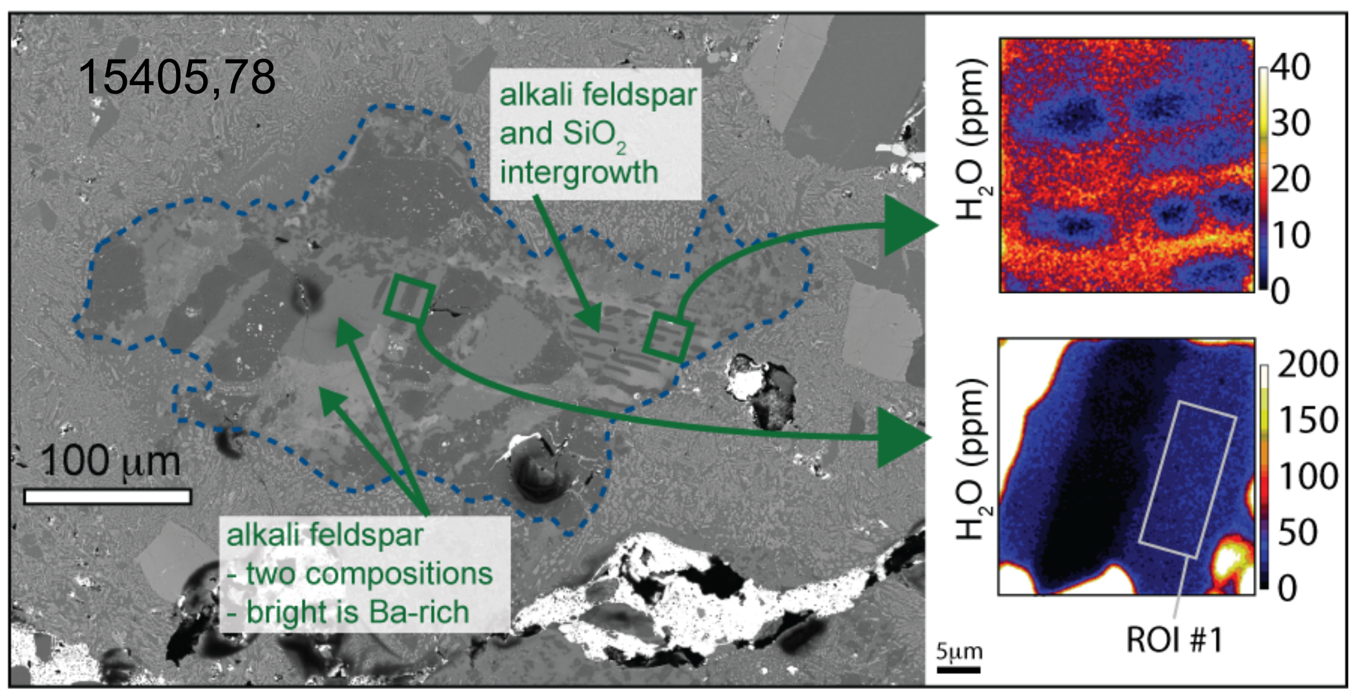
Apollo Sample Studies: Silicic Volcanic Processes on the Moon

K-Ca Isochron for lunar granite indicates silicic magmatism 4.03±0.07 billion years ago.



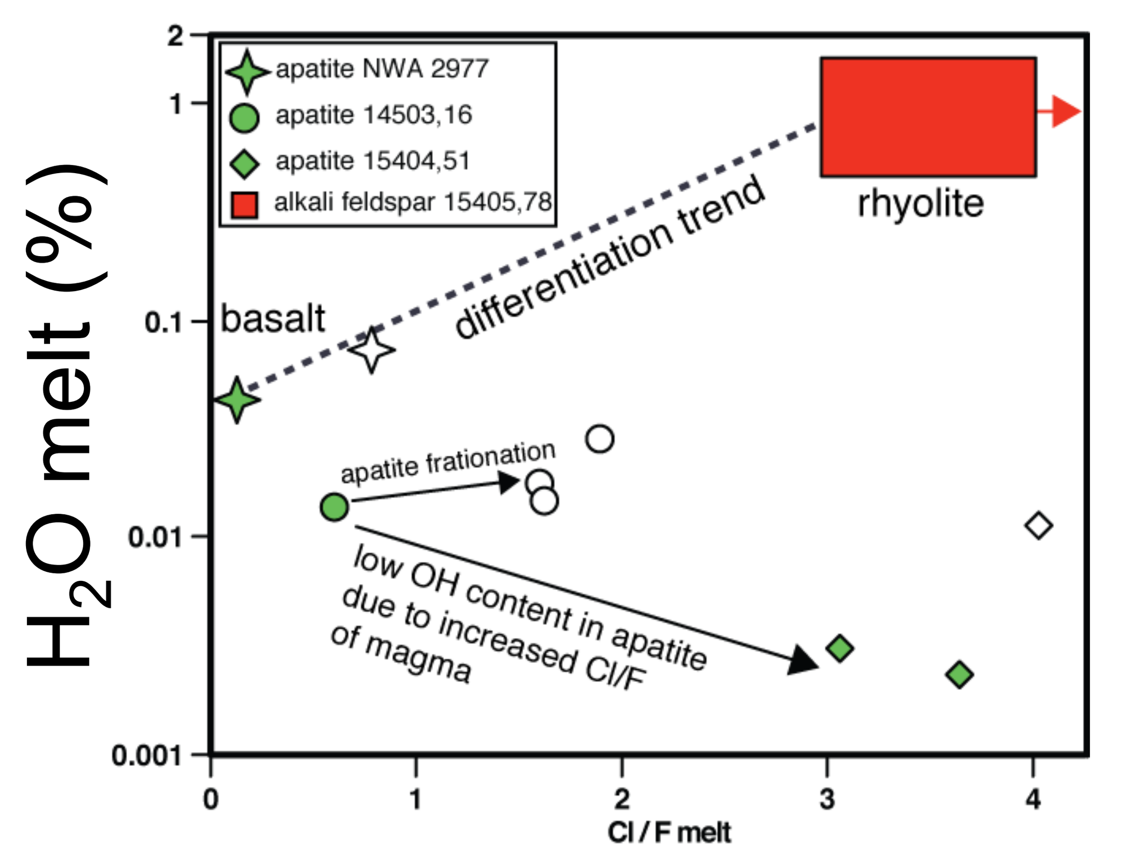
The initial $^{40}Ca/^{44}Ca$ composition when compared to primitive lunar crust (e.g., FAN 15415) indicates that it was derived from a relatively enriched source that has a K/Ca ratio (~0.7) that is equivalent to terrestrial andesite.

Alkali feldspar from granitoids on the Moon have measurable water.



On right are chemical maps obtained by NanoSIMS. Water correlates with mineralogy. The alkali feldspar consistently has ~20 ppm H_2O. The silica phase has similar water contents as the blank obtained on anhydrous glass (~ 2 ppm).

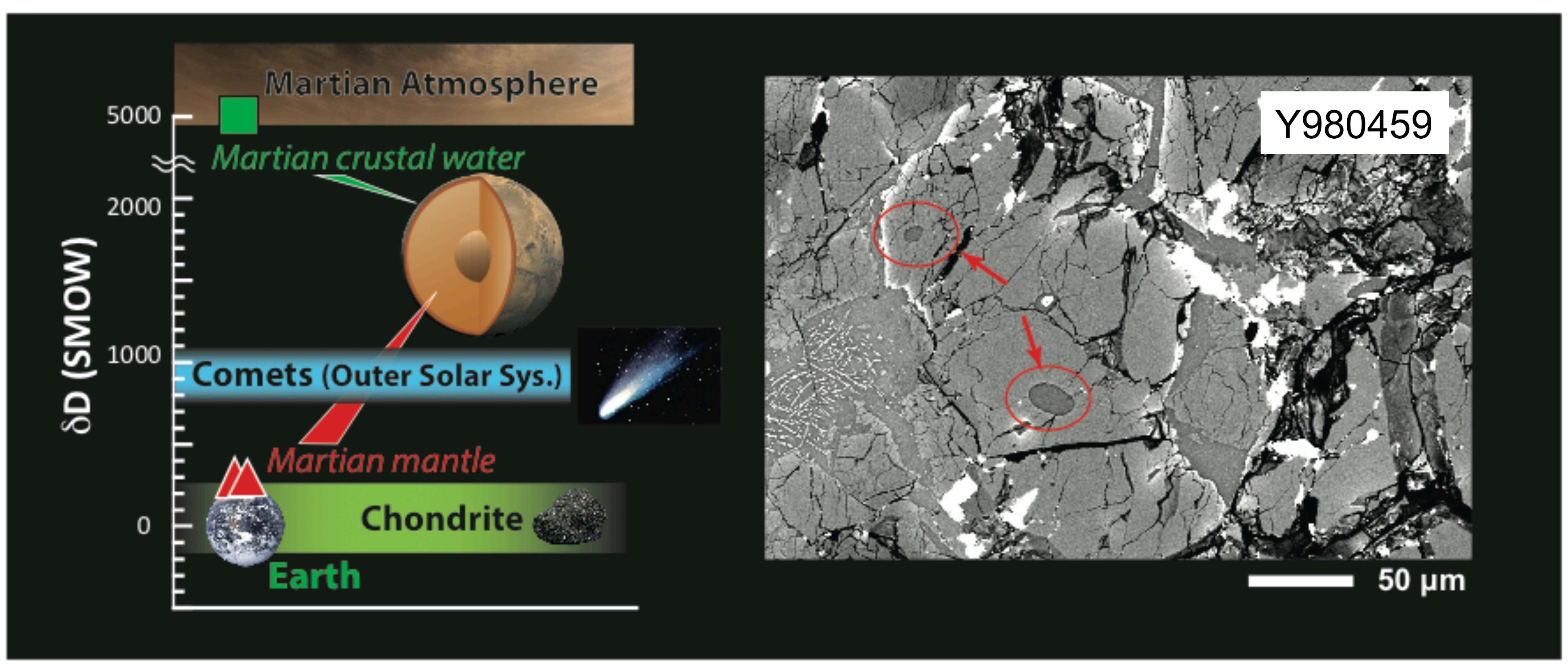
Felsic magmatism on the Moon likely removed significant amounts of water from the mantle during primary and secondary crust formation.



Using the published range in distribution coefficients of 0.0015 – 0.004 we obtain an estimate of 0.5 to 1.3 wt % water in the felsic lunar melt.

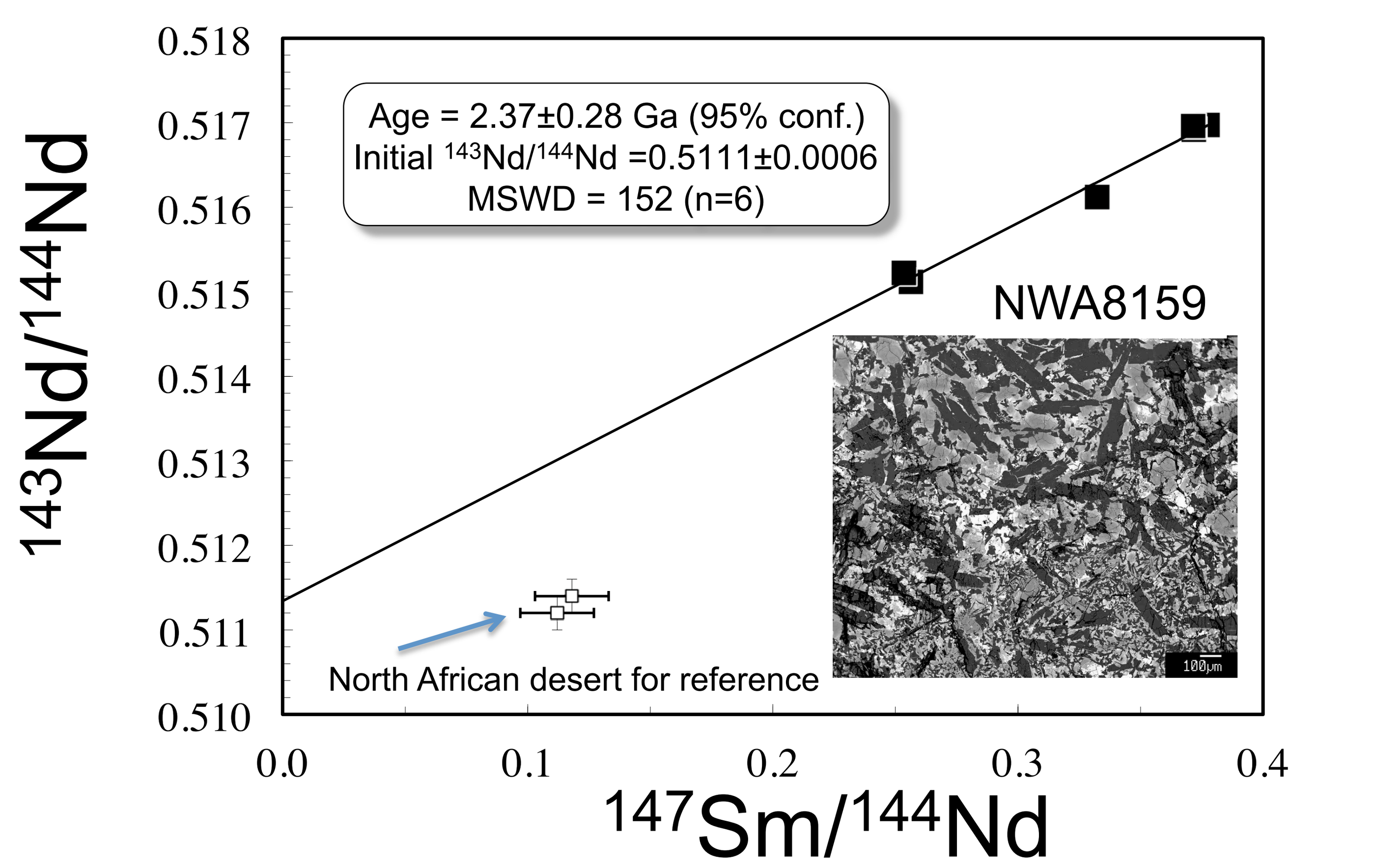
Martian Meteorite Studies: Evolution of Martian Crust and Hydrosphere/Cryosphere

Hydrogen in the martian interior accreted from planetary building blocks similar to those that formed Earth, like chondritic meteorites, and not comets.



Hydrogen isotopic signatures of martian surface water (green square) and primordial water (red triangle) observed in the martian meteorites LAR06319 and Yamato 980459, respectively (left). A new hydrogen reservoir on Mars has also been discovered (anticipate a press release soon!).

A recently discovered martian meteorite expands our samples suite and thus our understanding of Mars.



Sm-Nd isochron yields evidence of volcanism on Mars ~2.3 billion years ago. Initial $^{143}Nd/^{144}Nd$ composition implies it was derived from a geochemically depleted mantle source. This time period in martian history has not been seen before in the rock record.

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